A Group Conformation Method using TQD Test as a support for Collaborative Learning Strategies Development

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Abstract: The aim of this paper is to propose a method to constitute working groups for a Collaborative Learning Environment which is integrated to an Intelligent Tutoring System in a Multi-Agent architecture. The proposed method is based on the results given by the Triadic Quotient Detector Test whose main function is to classify students according to their dominant brain structure and thus to determine what roles they can play within the collaborative learning group. This information is used by the system in order to distribute the students in a balanced way into working groups when a collaborative learning strategy is being developed.

Keywords: E-Learning, CSCL, Group Conformation Method, TQDT-Triadic Quotient Detector Test, Collaborative Learning Strategies, JIGSAW.

1. Introduction

Taking into account the need to implement activities that allow improvement of students educational skills, not only from the individual point of view, but also from the group perspective, in this paper a method is proposed for conforming collaborative learning groups, which facilitates the successful development of their abilities resulting from the interaction with other students, while they are developing collaborative activities within a CSCL (Computer Supported Collaborative Learning) framework.

Working groups are essential pillars during Teaching /Learning processes. They are a complement to individual activities and knowledge reinforcement, which generates practical, argumentative and analytic richness in the student, because, while they are interacting and discussing with others abilities are stimulated, which cannot be developed in an individual way.
In collaborative learning development, the application of learning strategies that implement effective action plans, in order to reach specific goals is necessary. In fact, such strategies facilitate the interaction between individuals, by means of proposing methods useful in building various kinds of activities, based on the different participant’s profiles.

The assignment of an adequate strategy to a given working group, has an impact on its performance; for this reason, it is essential to choose a suitable strategy, as that determines the success or failure within the knowledge acquisition process of the students. Such strategy is directly related to the activity that is developed, for example reading, workshop or researching. This papers aim is to propose a method for working group conformation based on both the Collaborative Student Model, already proposed in [11], and the Triadic Quotient Detector Test (TQDT) [5].

Within the project entitled “Adaptive Intelligent Virtual Courses” (CIA) developed by GIDIA (Research and Development Group in Artificial Intelligence) at the National University of Colombia – Medellin Campus, we are designing and implementing a group conformation method in order to improve the development of the proposed collaborative strategies.

2. Theoretical Framework

The Computer Supported Collaborative Learning (CSCL) approach derives from the research field of Computer-Supported Cooperative Work (CSCW), that refers to a group of people working together at a common working environment, favoring group interaction with the support of computational tools [20].

Johnson et al. [11] define collaborative learning as: the “institutional use of small groups in which students work together with the aim of maximizing their learning and that of their mates”, identifying five essential components: Positive interdependence, interaction, individual responsibilities, personal, and group abilities. The positive interdependence component as defined by Collazos et al. [1], is at the heart of collaborative activities. It is important to establish, that it is not enough to get the group to work in a cohesive way to reach positive interdependence. The positive interdependence is the reason by which the group has to collaborate, and in this way the group work becomes a collaborative work.

In collaborative learning, the application of learning strategies is necessary, these are defined as a set of activities, techniques and means that are accordingly planned to the target population needs, the goals they pursue, and the nature of the field domain and courses. Also, learning strategies can be defined as procedures and resources, used by a teaching agent in order to encourage significant learning in students [13].

Such strategies must implement suitable activities to improve the Teaching/Learning process, of both the students individually and as a group, thus
achieving a better performance in order to reach the proposed objectives. This process favors interaction between individuals, because the strategies use methods for performing various activities that can be linked to diverse participants’ profiles. These profiles can be obtained through tests, activity monitoring, and other techniques.

Even though there presently are several collaborative learning strategies, the ones that have been used for this work are: “Guided reciprocal peer-questioning” and “JIGSAW”. According to the nature and performance of these strategies, we decided to form groups of three students.

**Triune Brain Model**

The Triune Brain (or Triadic Model) establishes that the human brain is made up of three brain structures, according to MacLean [7]:

- The neocortex composed of the right hemisphere and the left hemisphere. The left hemisphere is associated with the processes of logical reasoning, analytical functions and decomposition of the whole is its parts. The right hemisphere where associative, imaginative, and creative processes occur, is associated with the ability to see in a global way and establish spatial relations.
- The second level or structure is comprised of the Limbic System, which contains six structures: thalamus, amygdala, hypothalamus, olfactory bulbs, septal region and hippocampus. In this system emotional processes occur, the state of warmth, love, joy, depression, hatred, etc., and processes related to our basic motivations.
- The third level is the Basic Brain or Reptilian Brain where processes related to values, routines, habits and behavioral patterns in the human being occur.

According to Waldemar De Gregori [5], the brain and its three main processes, logical-scientific-rational side; intuitive-spiritual-mystic-proactive and visionary side; and central-organizational-administrative of economic production side, must be used and developed in such a way that an individual is able to take advantage and utilize all the capacity of the brain. De Gregori proposes, designs and validates, the utilization of the Triadic Quotient Detector Test (TQDT) [5], to take a snapshot of the state of the three main brain structures and is therefore able to assess learning processes in individuals, as well as in working groups.

The triune or triadic brain is proportionally, or disproportionally, exhibited in the behavior of the student and thus affects the student’s educational and social performance. In consequence it is necessary to characterize each person through TQDT, with the aim of consciously influencing development of operations, abilities and mental faculties, specifically the ones related to thinking, creating-imagining-feeling and realizing-acting.
3. Background

The collaborative environment Synergeia, as described by Stahl [12], is designed to support collaborative knowledge construction within classrooms. It provides a common and structured vision based on the Web. In this way, it is a collaborative work space in which learning process can be carried out; documents and ideas can be shared, debates can be stored, and the artifacts and knowledge can be developed and presented.

This system which is based on the BSCW (Basic Support Cooperative Work) approach is presented as a tool that implements cooperative work, which moves away from our “collaborative” approach in order to reach individual learning progress based on group collaboration.

ESCOLE (Environment for Supporting COllective Learning Enthusiasts) [6], is a platform that provides basic cooperation services, CSCL tools and instruments, accessible from different remote work places. The set of basic cooperation tools include production tools (e.g., shared editors), communication tools (e.g. e-mail, news, forum, chat, wiki, etc.) and coordination tools (e.g. shared calendar, survey service, among others).

The system gStudy [14] allows a student or tutor to create or import contents on almost every issue. The information about topics is specified using HTML language, which can include text, photos, graphics, tables, audio, and video clips, i.e. the common information formats for the library of printed and Internet resources. Finally, the gStudy system provides cognitive tools for the students to create, share, exchange information and objects.

In both the ESCOLE and the gStudy projects, it is not clearly established how the simple fact of providing collaborative tools, can achieve the attainable outcomes in student’s learning process. This issue may be related more accurately to cooperative work than collaborative learning; furthermore, they do not implement learning strategies defined for individuals.

Although they obtain results from collaborative learning, both Synergeia, ESCOLE and gStudy do not have any specific mechanisms to constitute the groups required to support collaborative learning strategies.

I-MINDS [10], is an intelligent Multi-Agent System (MAS) for Collaborative Learning and classroom management. This system is made up of intelligent software agents, collaborative tools, and implements a learning strategy called JIGSAW. In addition, one of the agents that comprises the system, the group agent, is in charge of building students profiles based on the behavior they display within the system, (who they communicate with, the kind of questions, etc.), this profile is later used to perform the working group conformation.

The CIA project currently developed by our research group has many similarities with I-MINDS, regarding the approach taken from MAS, CSCL, and learning strategies, however, it differs with these because within CIA’s architecture we implemented besides JIGSAW another learning strategy called “Guided reciprocal peer-questioning technique” and a method used for group
conformation which is based on the TQD Test. Additionally, the knowledge models utilized here (domain, tutor, and student) take into account both perspectives based on individual and collaborative points of view.

**Collaborative Student Model**

The traditional ITS can adapt to users through the construction of a Student Model. Following this approach, within the CSCL based systems it is necessary to extend the scope of the Student Model in order to model the profile of every student and the entire group as a whole. We call this new version the Collaborative Student Model (CSM) [9]. The CSM is comprised of the Student Model and the Group Model [4] as shown in figure 1.

![Figure 1 Structural Diagram of CSM.](image)

The Student Model is extended by integrating a collaborative profile to it, since as it is established for ITS, this essential component contains relevant information for individual learning, but there are some important characteristics for collaborative learning that are not considered.

The Collaborative Profile includes the students’ collaborative abilities that they have shown within several collaboration contexts. We propose a collaborative learning model, designed to help the adaptive learning system to identify and achieve the group interaction in different problem domains. We take as a reference, the taxonomy of skills for collaborative learning exhibited in [11]. This divides each type of learning dialog skill in sub-skills, and for each sub-skill defines attributes.

Every attribute is assigned to a short introductory sentence, or a sentence opening, which drives to the appropriate dialog intention. Regarding the context definition, the following variables must be considered: Objective (concerns to group objectives), Group-type (describes the group conformation and structure), Symmetry (explaining whether it is about a knowledge, action or state [2]), and Rules (explaining whether or not there exist rules to which the group must response).
The Group’s Profile contains data that identifies and describes the group as a whole. Here the following issues are considered: Group identification, the set of students that make up the group, group objective, shared beliefs by the students, mistakes made by the group, and the role that each student performs. This profile will be updated based on the interactions among the students and the system. In addition, data generated by the students while working together, should be monitored. At the beginning the group’s profile should be empty, and will not be taken into account in organizing the groups, however, if a student has information in this profile it will be taken into account for future group assignment and conformation.

4. The Group Conformation Method in CIA Framework

The proposed method for group conformation in the collaborative part of the system takes into account the characteristics of every student regarding group work, and their strong features, thus allowing them to integrate in the best way with the others, according to their collaborative abilities.

The student’s collaborative abilities are determined by means of the Triadic Quotient Detector Test (TQDT) [5], which is a test that allows us to know what the student’s mental model is regarding group skills. In addition, it can be used to diagnose the behavior expressions exhibited by influence of the triadic brain, which is made up of three brain structures: left hemisphere, right hemisphere, and central hemisphere. The main goal of TQDT is classifying the person who takes the test among one of these three categories, i.e. whether the person has a dominant left, right or central brain, and according to this, characteristics, roles and activities concerning to each one of these three classes are defined.

The outcomes of the TQDT are checked by the Group Supervisor agent in order to distribute students into groups, taking into account the fact that within every group the students have to be well distributed in such a way that there is a balance in the three kind of dominant brains and therefore to increase in this way the understanding, the interaction among students and thus to facilitate their learning process.

Basically, the group conformation method that is proposed in this paper is carried out in four stages [3]:

- **Stage 1**: The Group Supervisor verifies the group activities schedule looking for programmed activities. If there is any scheduled group activity, it is proceed with the next stage. If there are not already scheduled activities the Group Supervisor continues verifying the schedule until a group work activity is added.

- **Stage 2**: The system looks for all the students that fulfill the requirements, i.e. all the students that have studied the topic and have presented the assessments attaining all the instructional objectives which are requirements for the group work.
Stage 3: The number of groups is calculated based on the amount of students per group specified in the collaborative learning strategies. Furthermore, the amount of students to be in every group is calculated. For this, we decided that for the selected strategies and taking into account their performance, the optimal number is three participants per group.

Stage 4: Finally, the students are grouped according to the outcomes of the Triadic Quotient Detector Test; it is hoped that in the best case there can be in each group every kind of dominant brain, this is done by an algorithm that distributes the students taking into account the amount of students per group and four lists of students, one for each kind of brain (central, right, left or not dominant).

5. Implementation and Analysis of Results

The CSCL model proposed in this paper is integrated with a Teaching/Learning environment called CIA, which is a Web learning platform and is made up of two parts, one individual and one collaborative. CIA is based on a multi-agent architecture linked to a MySQL database.

As CIA is a Web oriented system, Servlets are required to communicate the multi-agent system with the graphical interfaces developed as JSPs. A Gateway agent is in charge of the communication between the system and the Servlets. The proposed design of this system has the characteristics of a distributed scheme in several ways, firstly, the current courses can be accessed via Web, because of the architecture, and secondly, the server that provides all the ITS and CSCL services is distributed internally because of the multi-agent systems design pattern, apart from being physically distributed.

The system is distributed on a LAN network: On the main server a Tomcat Web server is located and the main container is instantiated, within which, the agents provided by JADE are executed, they are: AMS, DF and RMA, also some system agents: Planner, Evaluator (ITS), Organizer, Supervisor (CSCL), because these agents have constant activity.

The design and implementation details of the multi-agent architecture are beyond the scope of this paper. Only the operation of the software agents involved in the collaborative learning process will be described. The Group Supervisor agent is in charge of controlling the collaborative learning environment, it automatically creates and organizes the students groups based on the information contained within the static and dynamic models of the collaborative strategies and also taking into account the TQDT [5], which allows organizing groups in a balanced way. It is important to make clear that every group created by the Group Supervisor agent is composed by students that have already fulfilled certain objectives in the individual process by the time that the planned group work is activated.
For the conformation of the groups, the Group Supervisor agent determines the number of groups and the amount of students that a group will hold, this is done by taking into account the number of students recommended by each strategy and the qualification that each one gets from the TQDT.

Once the calculation of the number of groups and students per group are done, the next step is the distribution of the students in the different groups. The distribution criterion assures that the groups are balanced by taking into account the kind of dominant brain hemisphere in each individual and the number of students required for every collaborative strategy.

**Analysis of Results**

The prototype that validates the proposed model was built for the research project named “Model of Multi-Agent System of Adaptive Courses integrated with Collaborative Learning Environments” [8]. This prototype allows the students to learn the basic concepts of a given course by adapting instructional plans for each student and performing a set of tasks in group.

When a student is enrolled in a course, the TQDT is presented to him in order for the system to store information concerning the student’s collaborative profile. Before group conformation, the Group Supervisor agent must wait until there are enough students to do the planned group work, taking in consideration the number of students required by each strategy. Because CIA system is still under development only two following strategies “Guided reciprocal peer-questioning”, and JIGSAW, are the ones completely operational within the system at the present time.

In order to instantiate the dynamic model (done by the Group Supervisor agent) at least one group work must be created so that by the start time of every group work the Group Supervisor agent performs one of the following tasks: building one or more groups of students according to the strategy, changing the state of the group work (from planned to in course) and creating the group timetable with all the activities to be done by the group participants. After that, the supervisor agent stores all the information concerning the group timetable (based on the strategy protocols that the group work follows) and the agendas of every student and facilitator.

When the static and dynamic concepts of a specific group work are instantiated and a student logs in the system, the Group Supervisor agent checks which activities are current and displays them with a link so that the student can access the tool to carry out the activity: forum, chat, e-mail, repository, etc.

In this way, each activity scheduled in the group timetable, is carried out for every student and the facilitator. It is important to clarify that all of the activities must be performed using a tool. When the group work is finished, the facilitator has to revise the work done by the students and enters a grade for each student.
4. Conclusions and Future Work

It is clear that virtual adaptive systems of Teaching/Learning are now playing a very important role in education because they facilitate and improve the learning processes. The integration of an individual environment such as an Intelligent Tutoring System (ITS) with a CSCL environment allows students to interact with others, so that they can improve their learning even more and also to reinforce the knowledge acquired during the process.

As shown in the survey of the state of the art, research work whose main objective was to improve the Teaching/Learning process, in general, either lack a collaborative learning strategy for performing group activities, or they lack of an effective method for grouping students so that such activities can be carried out in the best possible way.

Because of this, in this paper a method was proposed for composing groups within a Teaching/Learning system which integrates an Intelligent Tutoring System with a Collaborative Learning Environment, under a multi-agent architecture. This method was designed and implemented in a computational prototype named CIA, which permits the conformation of work groups which use CSCL strategies for doing group activities, thus allowing a more effective Teaching/Learning process for every member of the group.

The proposed method is based on the entity-relationship model for Collaborative Environments which was proposed within the research project CIA, which extended the typical ITS individual Student Model, appending collaborative issues such as groups, strategies, tools, etc. to it. Additionally, the method uses the TQDT for determining the kind of dominant brain for each student, in order to make the best distribution of students in the groups so that the group activities can be carried out in optimally, assigning roles and activities to each member of the group depending on the typical characteristics of every kind of brain structure.

As future work, we intend to investigate the application and development of other methods for group conformation, taking into account other variables that can affect the development of individual Teaching/Learning processes. These methods will consider variables such as academic level, whether previous to course or during development of the same, as well as social behavior variables that refer to interpersonal relationships between students such as empathy, responsibility, efficiency, etc. From such methods we intend to make a more homogeneous and suitable group conformation in order to achieve a better performance of group activities depending on the applied strategy.

Finally, it is planned to make some formal experiments with actual students in order to evaluate the performance of the proposed method, this will be done by
conforming two types of groups, namely: one, from the proposed method, and other made up of random students. In this way, a comparison will be made between the approaches to determine whether the results are better using the proposed method when working collaboratively.

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